# A 19-year time series of 1-km AVHRR satellite data of the conterminous United States and Alaska

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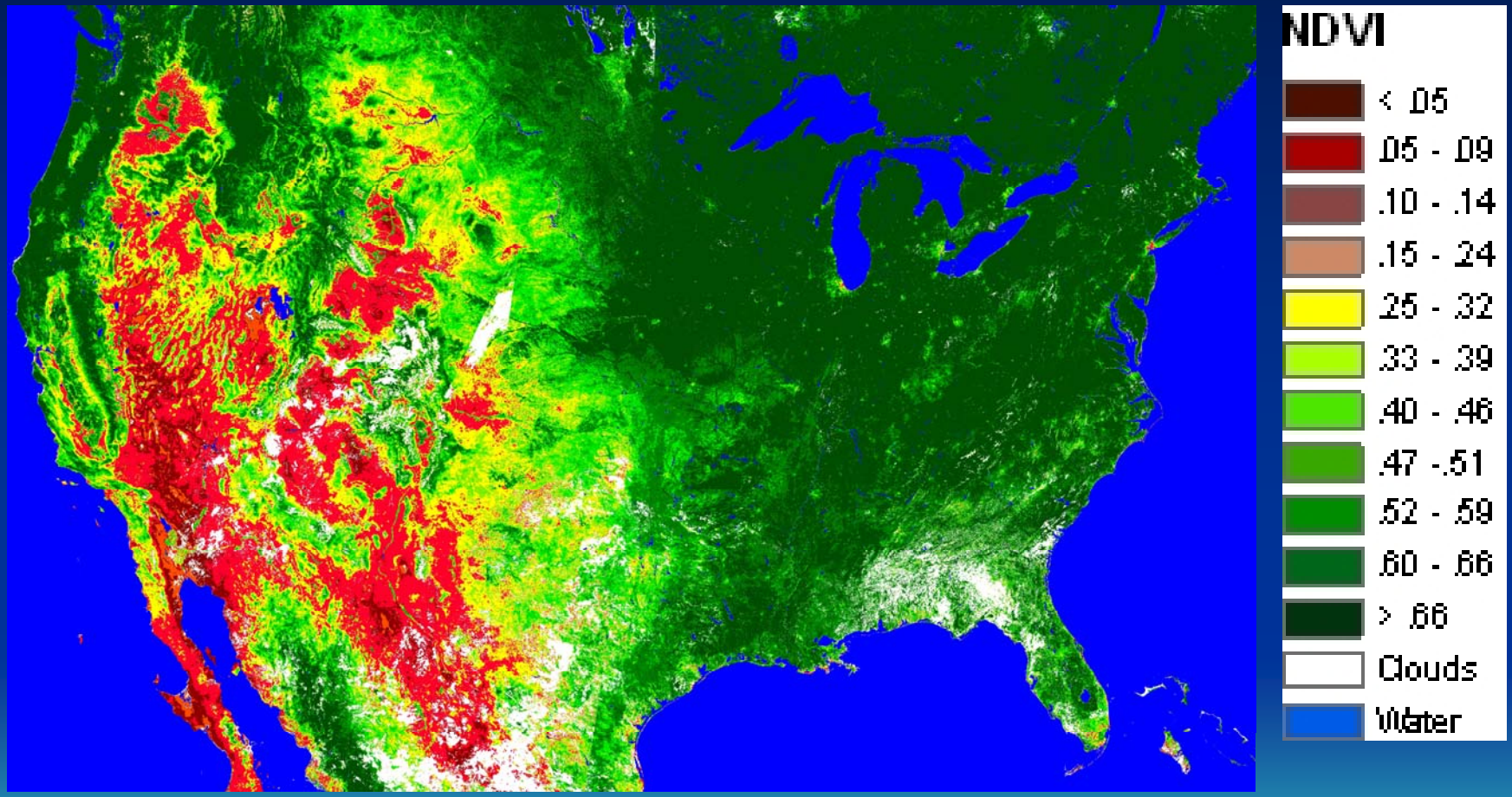
# What is the conterminous US and Alaska greenness data set?

- 19 year time series of
  - weekly  and biweekly maximum Normalized Difference Vegetation Index (NDVI) composites derived from 1-km AVHRR data
  - Historical average weekly greenness
  - Historical minimum greenness
  - Historical maximum greenness

# Conterminous US Greenness Map
# August 9, 2005

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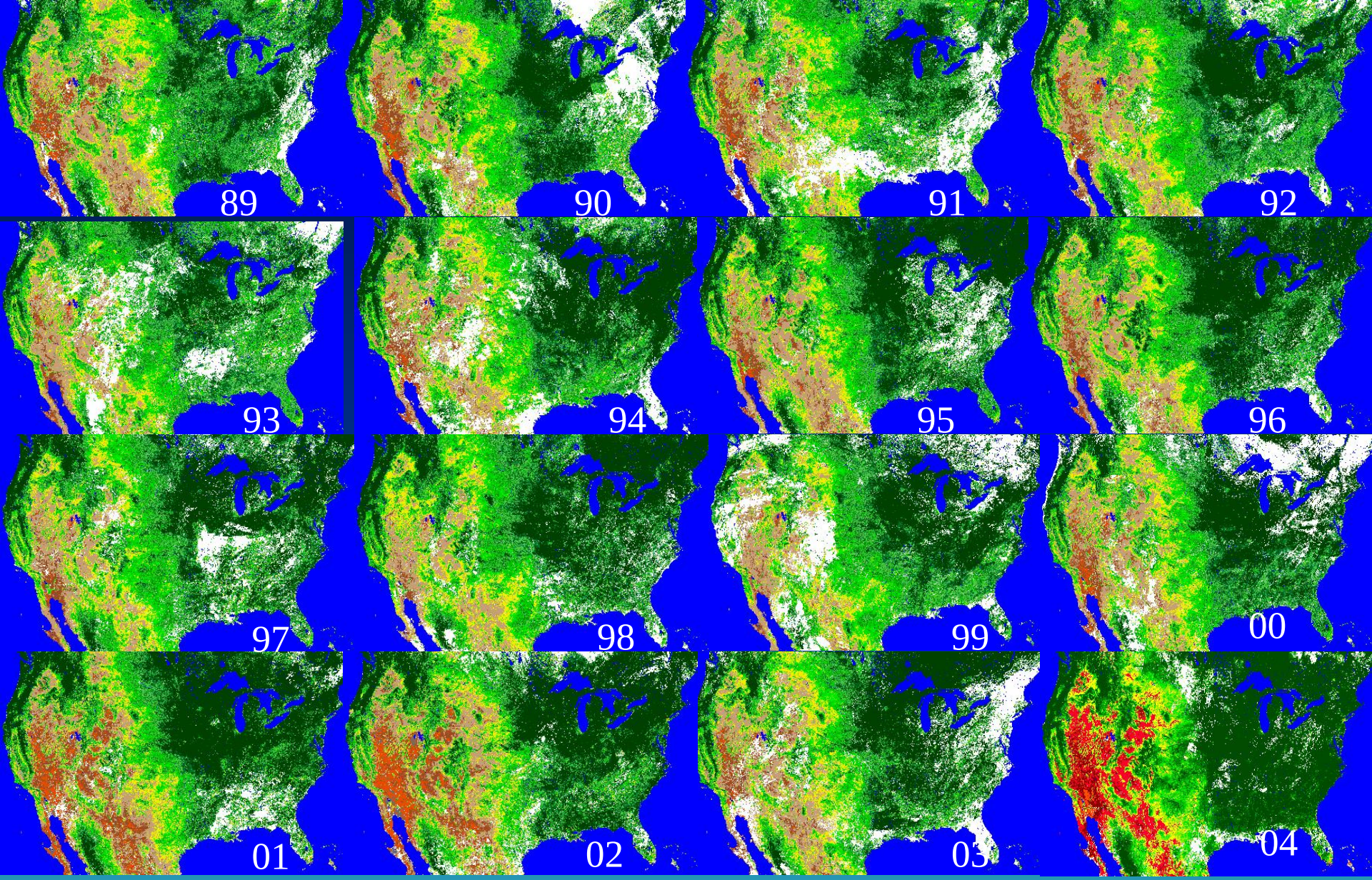


August 6, 1989-2004

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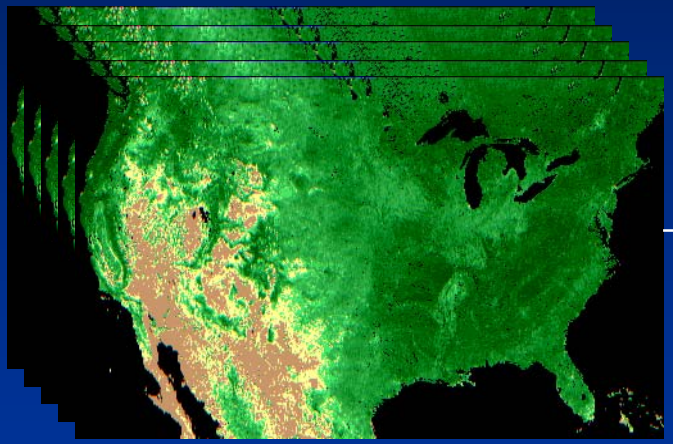
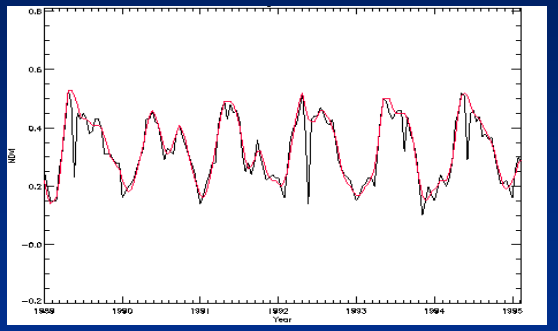
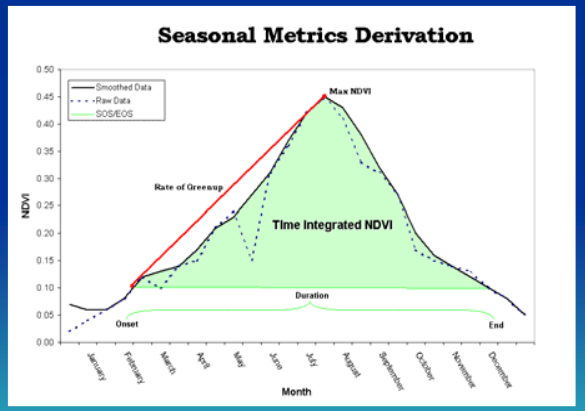
# 19+ years of Greenness data permits studies of relative condition of land surface






Start of Season
End of Season
Length of Season
Growing season greenness
Greenness “to-date”

# Processing Methods

- Geometric Registration
  - Control point matching
  - So clouds obscure ground locations
  - So not all scenes can be registered
  - Accuracy <1km RMSE

# Processing Methods

- Radiometric Correction
  - Data from NOAA-11, -14, -16, and -17 AVHRR sensors have been used to produce the conterminous United States and Alaska data sets. The source of the calibration coefficients for each sensor varies, but the basic method used to develop and apply the coefficients is very similar

# Radiometric Calibration

| Satellite | Start Date | End Date | Source |
|---|---|---|---|
| NOAA-11 | 09/26/1988 | 03/26/1989 | prelaunch |
| NOAA-11 | 03/27/1989 | present | Teillet and Holben (1994) |
| NOAA-14 | 12/30/1994 | 06/30/1995 | prelaunch |
| NOAA-14 | 06/31/1995 | present | Vermote and Kaufman (1995) |
| NOAA-16 | 09/01/2000 | 06/24/2003 | prelaunch |
| NOAA-16 | 06/25/2003 | present | NOAA |
| NOAA-17 | 01/01/2004 | present | NOAA |

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# Atmospheric Correction

- Application of an atmospheric correction for ozone, water vapor absorption, and Rayleigh scattering.

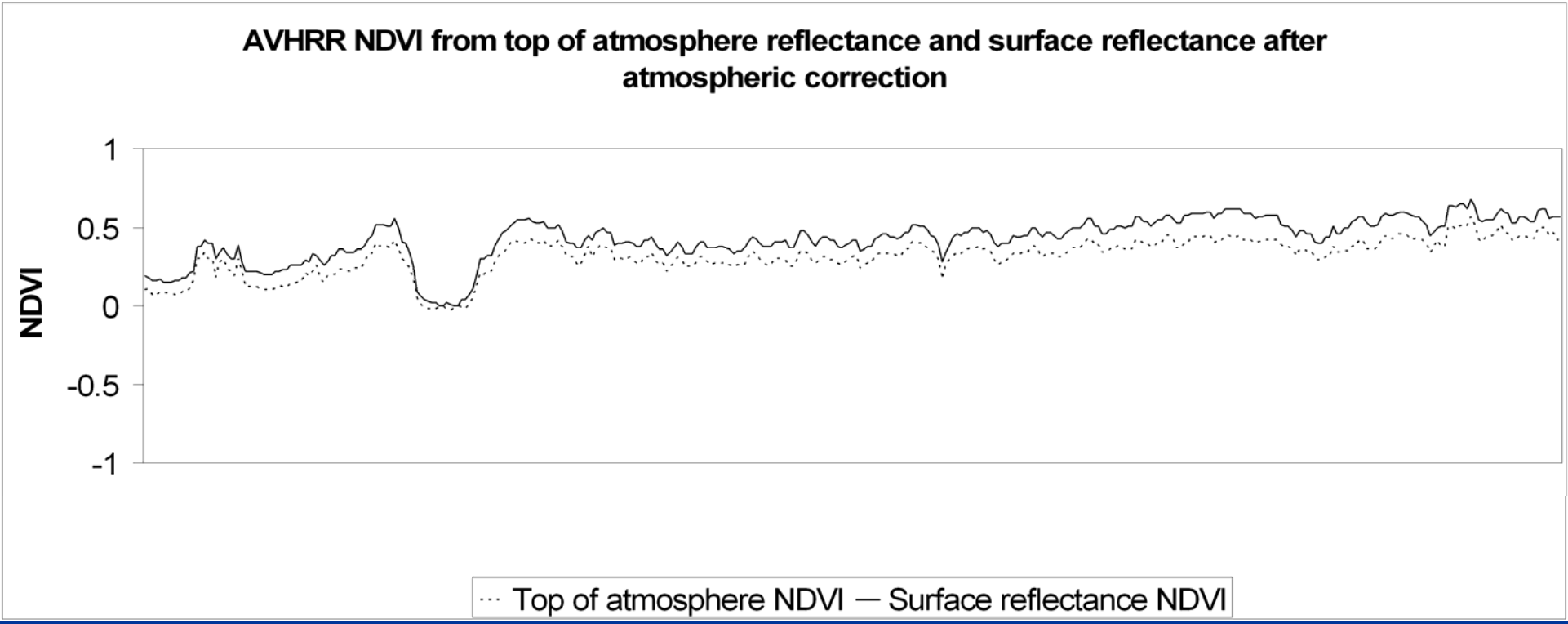
- In 2001, the entire existing time series was reprocessed to include the atmospheric correction, which has been applied routinely since 2001.

# Atmospheric Correction

- Water vapor absorption affects measurements in the near-infrared band (channel 2) by reducing the reflectance by 10–30 percent, depending on the viewing geometry (Tanre *et al.* 1992).
- Rayleigh scattering and ozone absorption affect measurements in the red band (channel 1) by increasing the reflectance by 1–2 percent, depending on the viewing geometry.
- The combination of these effects the computation of NDVI.

NIR - Red / NIR + Red

# Improving Sensitivity



# Improved Cloud Screening

- Old method
  - Simple threshold of channel 1 (red) brightness
    - Does not work well over bright soils (desert southwest)
    - Does not work well with thin clouds over dark surfaces

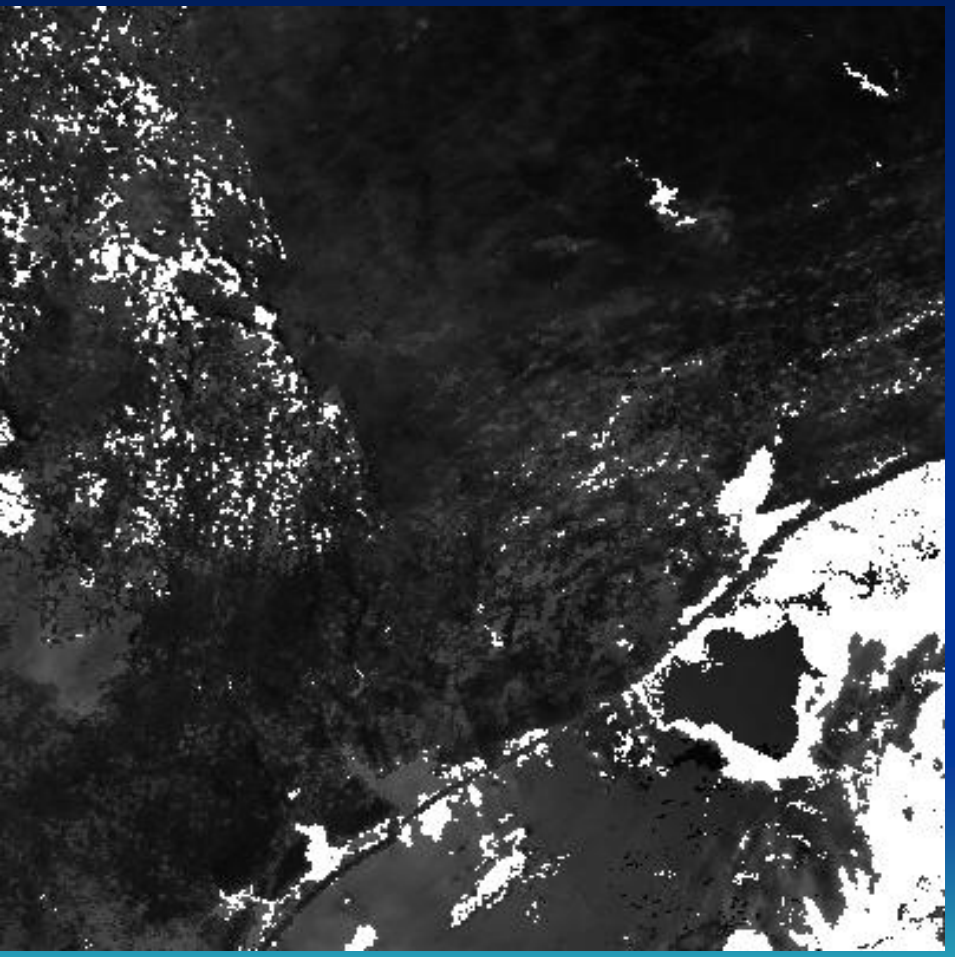
# Improved Cloud Screening

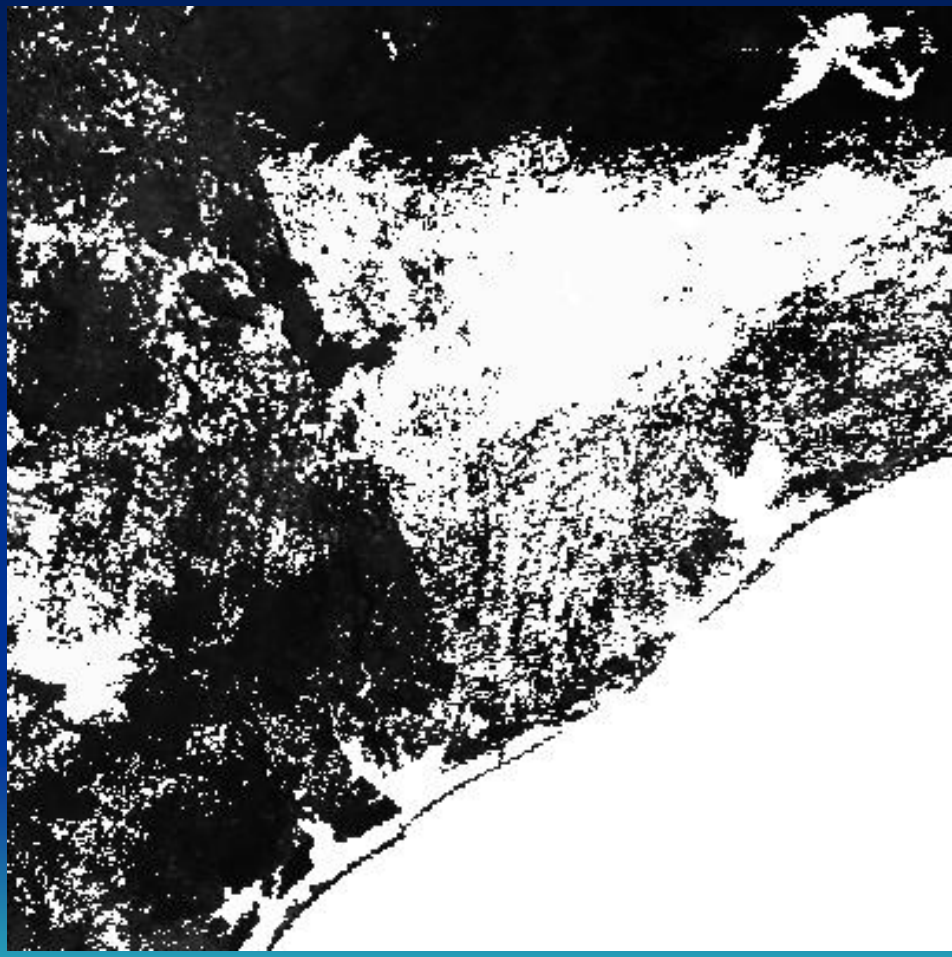
- New method
  - Use modified Clouds from AVHRR (CLAVR) method (Stowe et al 1999)
    - Series of test using brightness, surface temperature thresholds and ratios, simple vegetation index, latitude, barren land mask
    - Modified for use on composites by eliminating spatial tests

# Area of thin clouds over dark surface

Brightness threshold

CLAVR method





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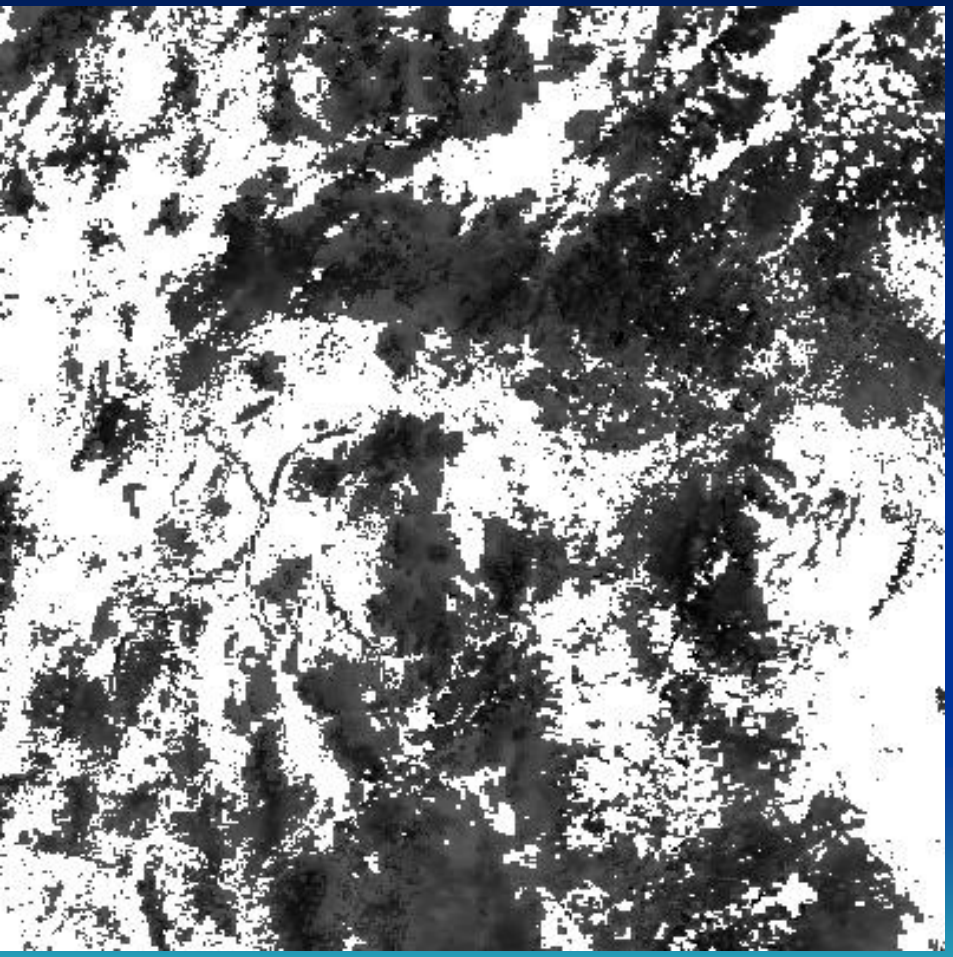
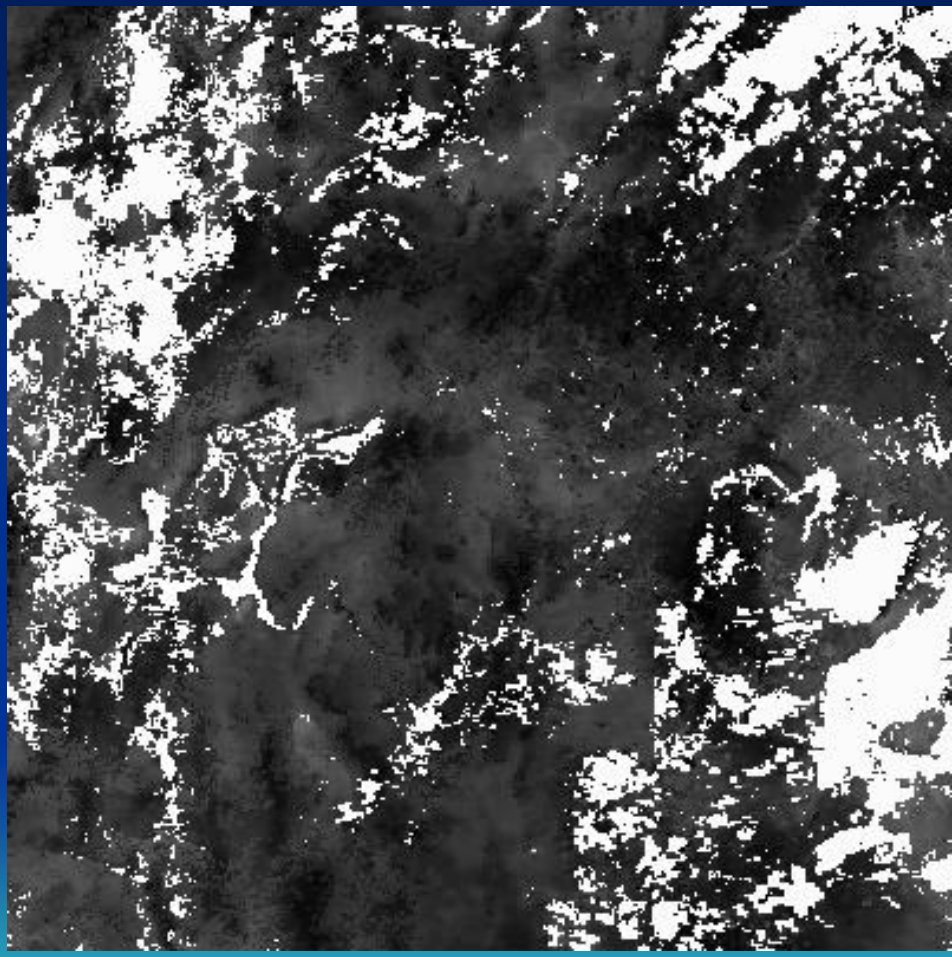
# Bright surface in desert southwest

Brightness threshold



CLAVR method



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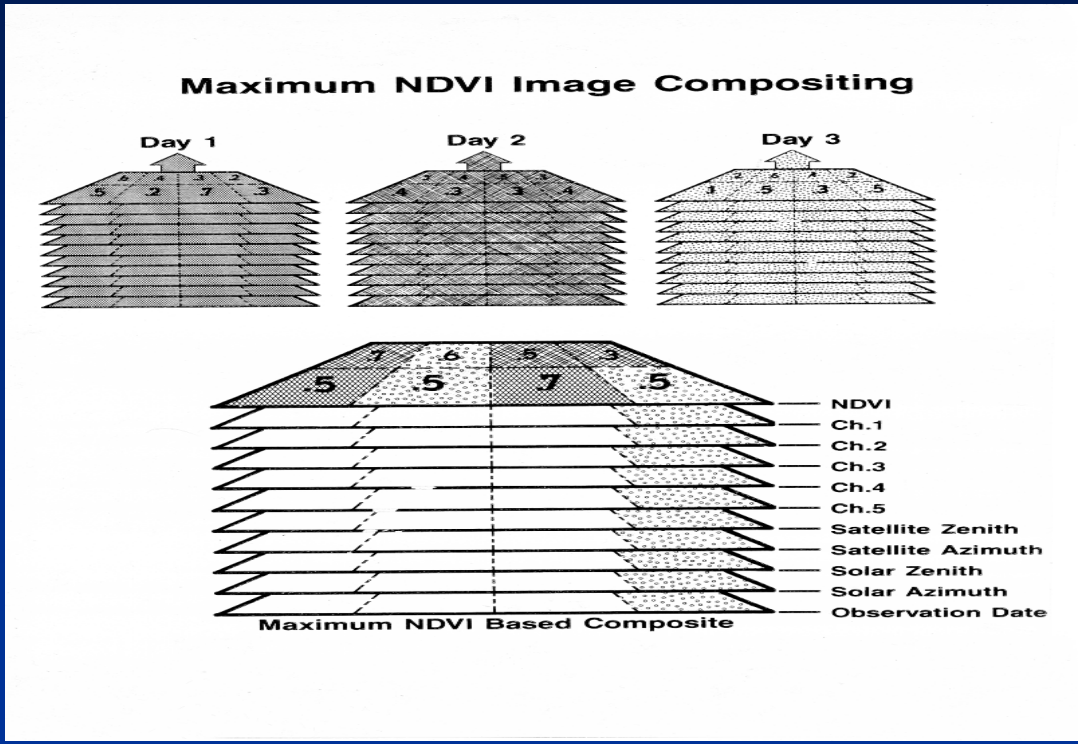
# Compositing

- Weekly and biweekly composites
- Using the maximum value compositing (MVC) method (Holben 1986).
- The maximum NDVI is assumed to represent the maximum vegetation “greenness,”
- Two geometric criterion are used in the compositing:
  - pixels with a solar zenith angle greater than 80 degrees are not used
  - Pixels >45$^{o}$ off nadir are not used



# Anomaly Products

- Anomaly products characterize the NDVI in terms of growing season status. These products are: visual greenness (VG) , relative greenness (RG), and departure from average (DA)
- Visual greenness maps portray current NDVI compared to a standard value that represents a very green reference such as an alfalfa field. VG is calculated using the formula:

$VG_t = NDVI_t / 0.66 * 100$

where:

$NDVI_t$ is the NDVI value for the current composite period

0.66 is a typical maximum NDVI observed over dense green vegetation

- Visual greenness values range from 0 to 100.

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# Anomaly Products

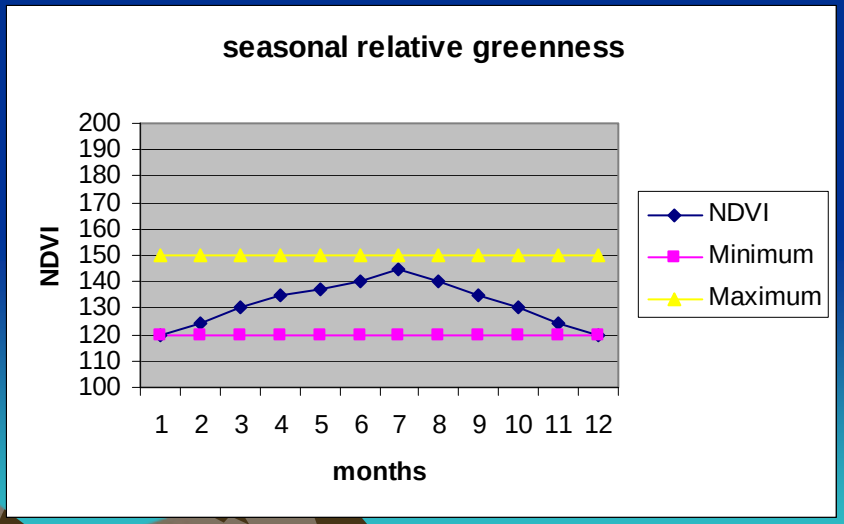
Relative greenness (RG) maps indicate current vegetation greenness compared to a historically observed NDVI range. RG is calculated using the formula:

$RG_t = (NDVI_t - Min) / Range * 100$

where

$NDVI_t$ is the NDVI value for the current composite period
Min is the historical minimum NDVI value for a location
Max is the historical maximum NDVI value for a location
Range = Max - Min

Wide range means small incremental changes of ndvi are not significant
Narrow range means means small incremental changes of ndvi are significant

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# Anomaly Products

- Departure from average (DA) contrasts current-year greenness with average greenness for the same time of year. The DA is calculated using the formula:

$DAt = NDVI_t/NDVI_{mt}*100$

where:

$NDVI_t$ =NDVI for the current time period

$NDVI_{mt}$ =mean NDVI for the current time period

$DA_t$=departure from average NDVI for the current period

- Positive departure from average values indicates that the vegetation is healthy and developing normally for the specific vegetation type. Low values during the growing season indicate that the vegetation is under stress, possibly from drought, or is behind in development.

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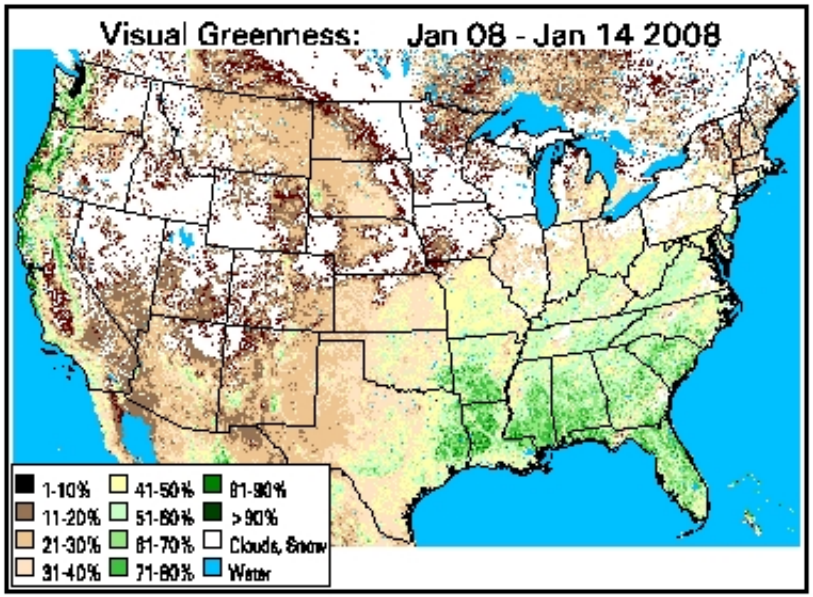
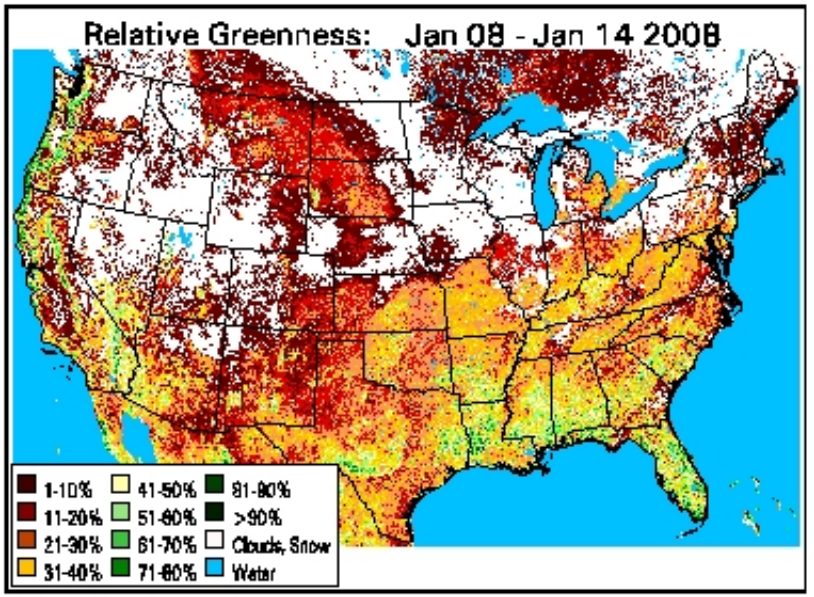
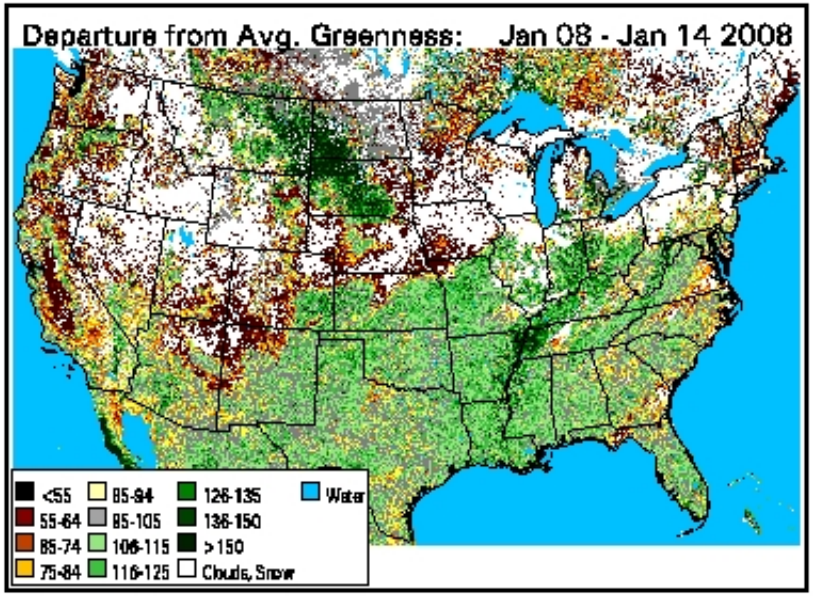

Visual Greenness: Jan 08 - Jan 14 2008
1-10%
11-20%
21-30%
31-40%
41-50%
51-60%
61-70%
71-80%
81-90%
>90%
Clouds, Snow
Water


Relative Greenness: Jan 08 - Jan 14 2008
1-10%
11-20%
21-30%
31-40%
41-50%
51-60%
61-70%
71-80%
81-90%
>90%
Clouds, Snow
Water


Departure from Avg. Greenness: Jan 08 - Jan 14 2008
<55
55-64
65-74
75-84
85-94
95-105
106-115
116-125
126-135
136-150
>150
Clouds, Snow
Water

# Improving the Data

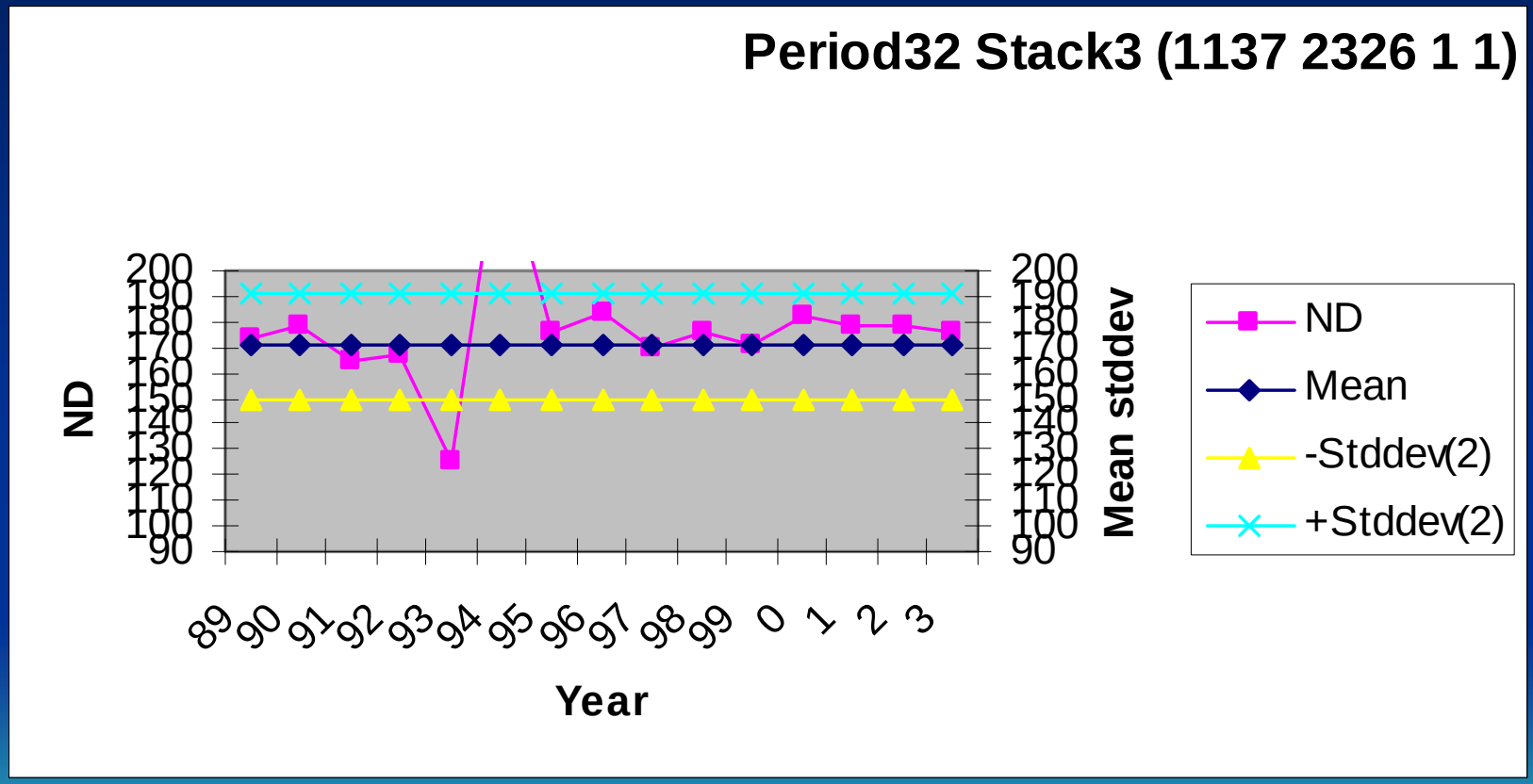
- Cloud contamination is a leading reason for lower minimum values, lower “average” values
- The lower values corrupt the metrics used to calculate the anomaly products

# Deriving the mean

- Mean computed from cloud free observations
- So the old mean was depressed by clouds
- Therefore, for any observation to be below normal, it had to be very low
  - Not sensitive

| Year | NDVI | Mean | -2stdv | +2stdv | cloud screened |
|---|---|---|---|---|---|
| 89 | 173 | 170.6154 | 149.6154 | 191.6154 | 173 |
| 90 | 179 | 170.6154 | 149.6154 | 191.6154 | 179 |
| 91 | 164 | 170.6154 | 149.6154 | 191.6154 | 164 |
| 92 | 167 | 170.6154 | 149.6154 | 191.6154 | 167 |
| 93 | 125 | 170.6154 | 149.6154 | 191.6154 | 125 |
| 94 | 250 | 170.6154 | 149.6154 | 191.6154 | |
| 95 | 176 | 170.6154 | 149.6154 | 191.6154 | 176 |
| 96 | 183 | 170.6154 | 149.6154 | 191.6154 | 183 |
| 97 | 170 | 170.6154 | 149.6154 | 191.6154 | 170 |
| 98 | 176 | 170.6154 | 149.6154 | 191.6154 | 176 |
| 99 | 171 | 170.6154 | 149.6154 | 191.6154 | 171 |
| 0 | 182 | 170.6154 | 149.6154 | 191.6154 | |
| 1 | 179 | 170.6154 | 149.6154 | 191.6154 | 179 |
| 2 | 179 | 170.6154 | 149.6154 | 191.6154 | 179 |
| 3 | 176 | 170.6154 | 149.6154 | 191.6154 | 176 |
| | | | | | |
| | | | | | 170.6154 |
| | | | | | 14.70566 |

Anomalous value

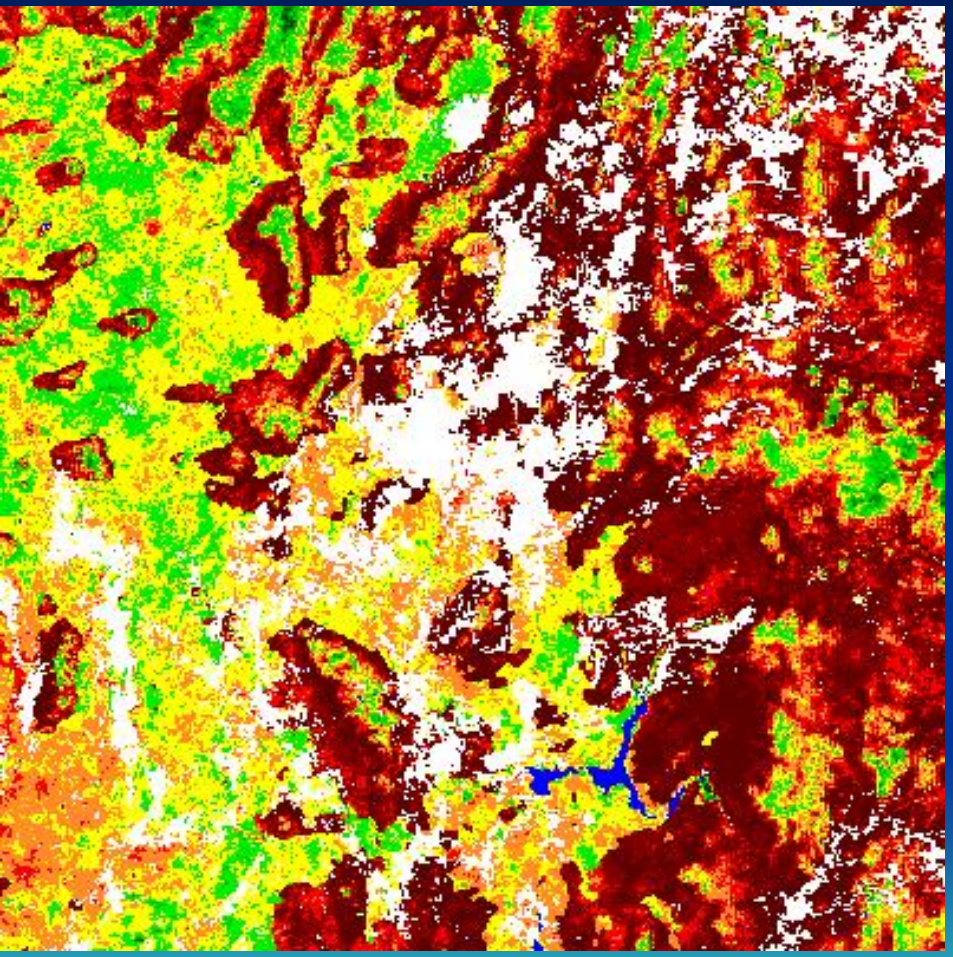

Period32 Stack3 (1137 2326 1 1)
ND
Mean stddev
200
190
180
170
160
150
140
130
120
110
100
90
89 90 91 92 93 94 95 96 97 98 99 0 1 2 3
Year
ND
Mean
-Stddev(2)
+Stddev(2)

| Year | NDVI | Mean | -2stdv | +2stdv | cloud screened |
|---|---|---|---|---|---|
| 89 | 173 | 163.4286 | 142.4286 | 184.4286 | 173 |
| 90 | 161 | 163.4286 | 142.4286 | 184.4286 | 161 |
| 91 | 145 | 163.4286 | 142.4286 | 184.4286 | 145 |
| 92 | 155 | 163.4286 | 142.4286 | 184.4286 | 155 |
| 93 | 154 | 163.4286 | 142.4286 | 184.4286 | 154 |
| 94 | 166 | 163.4286 | 142.4286 | 184.4286 | 166 |
| 95 | 170 | 163.4286 | 142.4286 | 184.4286 | 170 |
| 96 | 157 | 163.4286 | 142.4286 | 184.4286 | 157 |
| 97 | 169 | 163.4286 | 142.4286 | 184.4286 | 169 |
| 98 | 176 | 163.4286 | 142.4286 | 184.4286 | 176 |
| 99 | 174 | 163.4286 | 142.4286 | 184.4286 | 174 |
| 0 | 161 | 163.4286 | 142.4286 | 184.4286 | |
| 1 | 152 | 163.4286 | 142.4286 | 184.4286 | 152 |
| 2 | 164 | 163.4286 | 142.4286 | 184.4286 | 164 |
| 3 | 172 | 163.4286 | 142.4286 | 184.4286 | 172 |
| | | | | | |
| | | | | | 163.4286 |
| | | | | | 9.581346 |

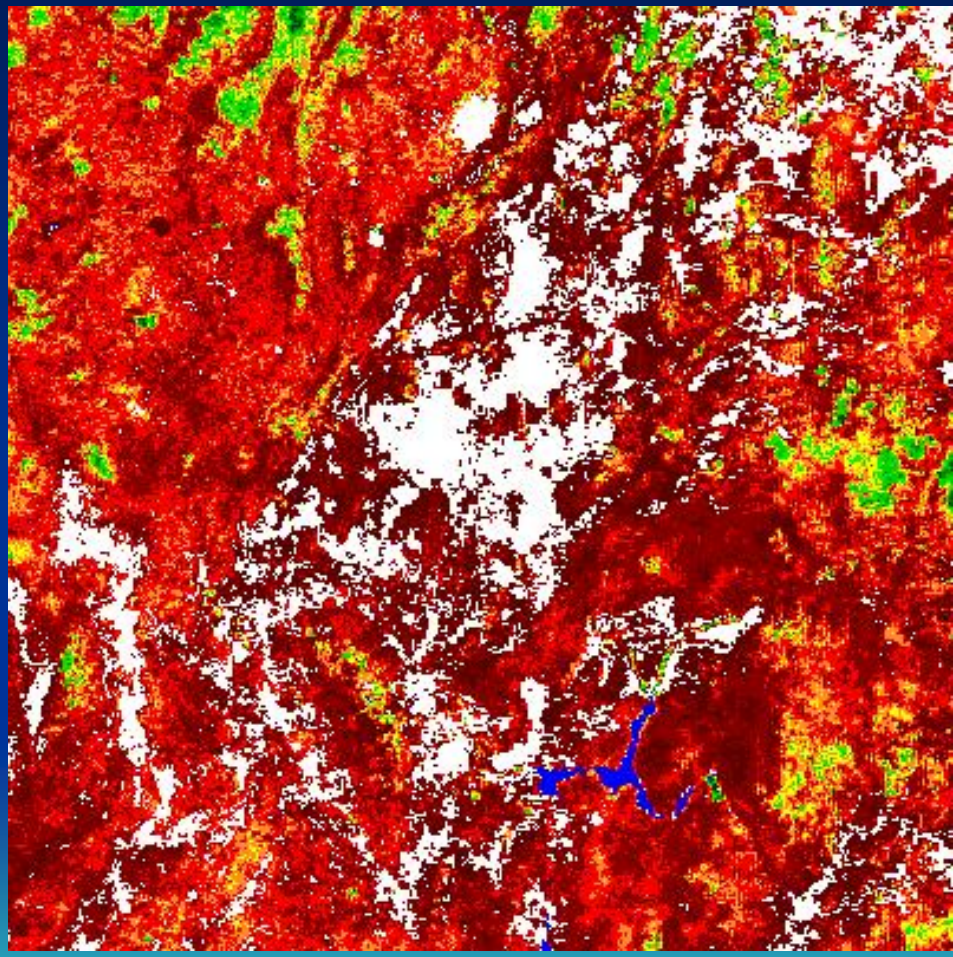
Anomalous value

# Southwestern US – Aug. 6, 2003

Old Relative Greenness



New Relative Greenness



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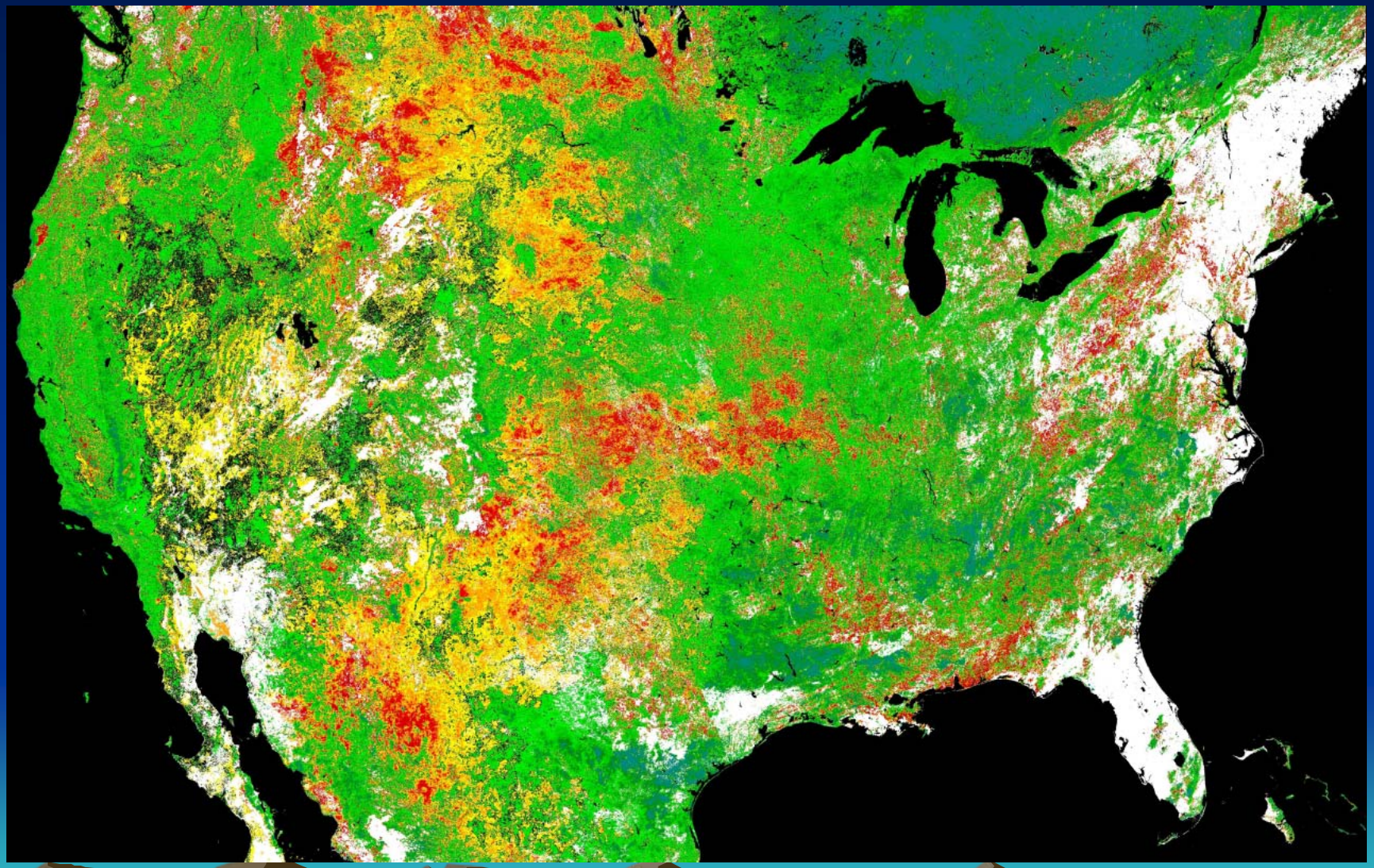
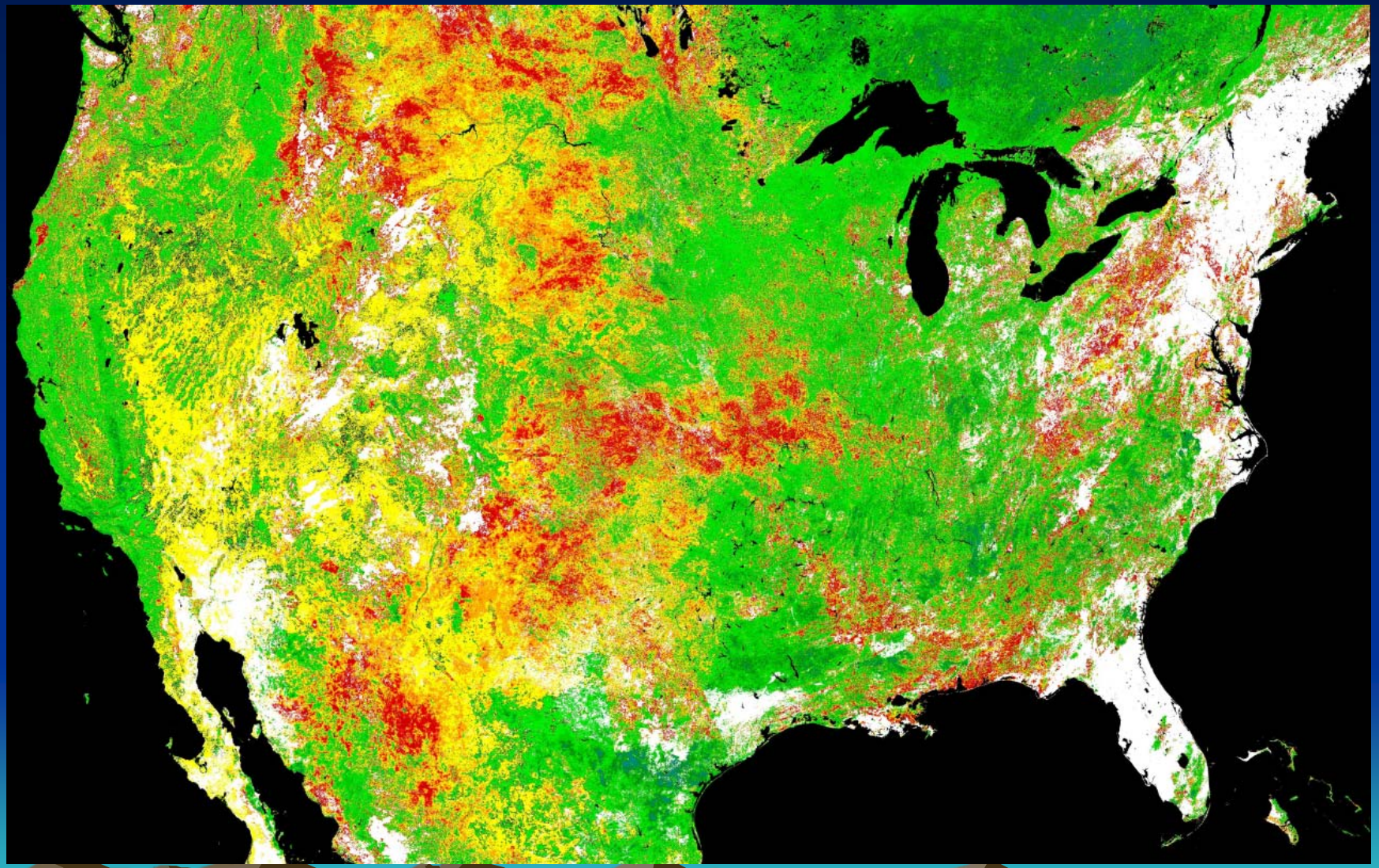
# Old departure from average



# New departure from average



# Product Description

- Calibrated data (Bands 1-5)
- NDVI (6)
- Satellite Viewing Geometry (Bands 7-9)
- Atmospherically corrected Red and NIR(Bands 10-11)
- Quality control (Band 12)
- Day of Acquisition pointer (Band 13
- Cloud mask (Band 14)

# Product Description

- The products are scaled to byte (8-bit) data.
- Reflectance values for channels 1, 2, and 3A are converted to byte data, where the range 0–254 represents 0–63.5 percent reflectance. The value 255 corresponds to reflectance greater than 63.5 percent.
- Channel 3B, 4, and 5 are converted to brightness temperature (Kelvin). Brightness temperatures a scaled to byte data. A scaling factor of 202.5 is subtracted from the brightness temperature value, and the difference is multiplied by 2 to maintain one half percent accuracy (i.e., a brightness temperature of 280 becomes 155).

# Product Description

- Resolutions
  - 1-km
- Map projection
  - Lambert Azimuthal Equal Area (CUS)
  - Albers Equal Area (Alaska)
- File format
  - flat binary raster, band sequential format
- Geographic extent
  - Conterminous United States (48 states) or Alaska

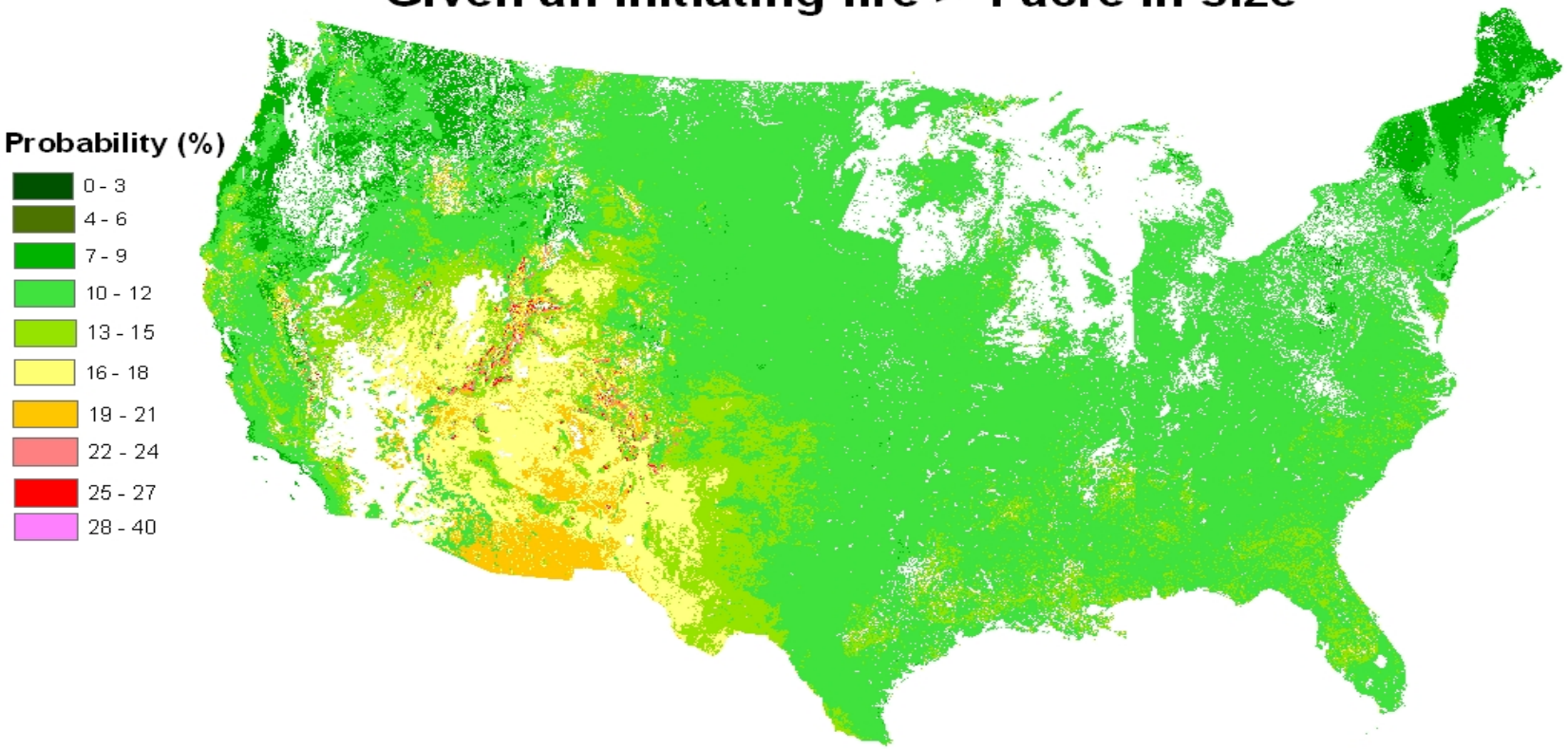
# Data Quality Issues

- The conterminous United States and Alaska data sets have no correction for stratospheric aerosol
- Orbital Drift of NOAA-14
  - Drift causes observation time to become later each day, for NOAA-14 it was beyond 5pm
- Cloud contamination
- Geometric accuracy

# Fire Danger Monitoring

- Predict probability of large fires
  - Use RG to characterize vegetation condition
    - Live moisture
  - Use weather model data to calculate dead fuel moisture (NAM)
  - Use NDFD to calculate 7-day forecast fuel moisture
  - Calculate fire potential index
  - Integrate historical large fire occurrence
  - Derive large fire probability

# Probability of a Fire Becoming Large - June 5, 2007
## Given an initiating fire > 1 acre in size

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# Data Access

- Free for download from USGS EarthExplorer (http://edcsns17.cr.usgs.gov/EarthExplorer/).
  - The individual composites are all 14 bands, compressed.

- Current composites and the anomaly maps can be viewed and downloaded at the USGS Integrated Vegetation Mapping (IVM) website (http://ivm.cr.usgs.gov/viewer).

- For further information contact:

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